EP22310 (2)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 5/06, 27/26

A1

(11) International Publication Number: WO 97/48206

(43) International Publication Date: 18 December 1997 (18.12.97)

(21) International Application Number: PCT/FI97/00279

(22) International Filing Date: 9 May 1997 (09.05.97)

(30) Priority Data:
962362 7 June 1996 (07.06.96) FI

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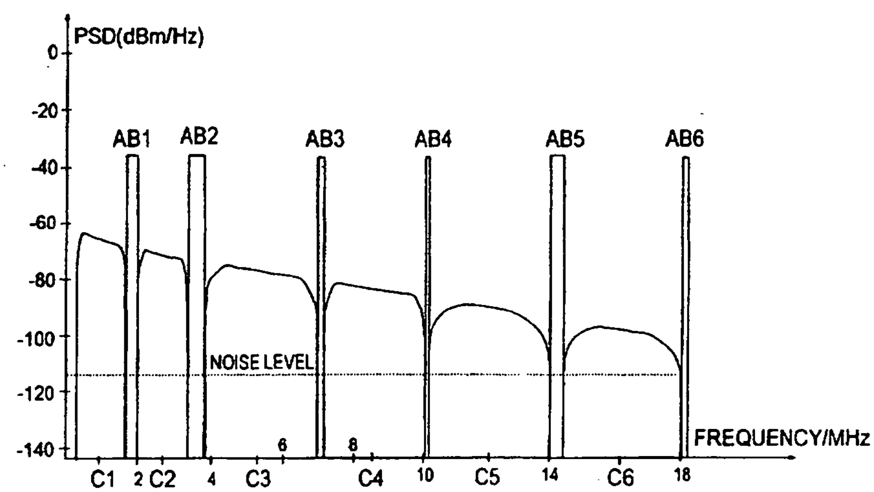
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.
In English translation (filed in Finnish).

(54) Title: METHOD AND APPARATUS FOR IMPLEMENTING A WIRELINE TRANSMISSION CONNECTION



(57) Abstract

The invention concerns a method and apparatus for implementing a wireline transmission connection, especially a VDSL transmission connection. The transmission connection is implemented in electric form so that a separate frequency range is reserved for either transmission direction. To allow efficient filtration of radio-frequency interferences by using as simple an apparatus as possible, the frequency band of the transmission line (13) is divided into sub-bands limited by international radio amateur frequency bands (AB1...AB6) and the transmission connection is implemented in at least some of these sub-bands (a) by generating for each sub-band to be used a carrier wave with its own modulator and (b) by dividing the bits of the bit stream (DATA_IN) to be transmitted between the modulators of the transmission direction in question so that each carrier wave is modulated with some of these bits.

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Method and apparatus for implementing a wireline transmission connection

Field of the invention

The invention relates generally to implementation of an electric wireline transmission connection, and especially to implementation of a transmission connection with the aid of VDSL (Very high bit rate Digital Subscriber Line) technology.

Background of the invention

Optical fiber is a self-evident choice as transmission medium for a trunk network, because trunk connections usually need a high transmission capacity, the transmission distances used are long and existing routes are often found for the cables. Even for subscriber connections (the line between the local exchange and the subscriber) the situation is rapidly changing, because various services implemented with multimedia and demanding a high transmission rate will be everyday services also from the viewpoint of the private consumer.

However, no significant savings can be expected in the costs of constructing future networks offering broadband services, because the costs arise mainly from cable installation costs. However, it would be desirable to build as much optical fiber as possible also in subscriber networks, because it can be clearly seen that it will be needed in the future. The costs of renewing subscriber networks are very high, however, and in terms of time decades are in fact at issue in this context. High costs are indeed the worst obstacle to the spreading of the fiber into subscriber networks.

For the reasons mentioned above, more efficient measures than before have been taken in order to find out how to utilize the conventional subscriber line (the metal wire pair) for high speed data transmission, that is, for transmission rates clearly above the rate (144 kbit/s) of the ISDN basic access. The present ADSL (Asymmetrical Digital Subscriber Line) and HDSL (High bit rate Digital Subscriber Line) techniques do indeed offer new possibilities for high-rate data and video transmission along the wire pair of a telephone network to the subscribers' terminals.

The ADSL transmission connection is asymmetrical in that the transmission rate from network to subscriber is considerably higher than from

subscriber to network. This is due to the fact that the ADSL technique is intended mainly for various so-called "on-demand" services. In practice, in the ADSL transmission connection the transmission rate from network to subscriber is in an order of 2...6 Mbit/s and from subscriber to network in an order of 16...640 kbit/s (a mere control channel).

The HDSL transmission technique concerns transmission in a metal wire pair of a digital signal of 2 Mbit/s level. HDSL represents a symmetrical technique, that is, the transmission rate is the same in both directions. The individual HDSL transceiver system comprises transceivers using echo-cancellation technology, which are interconnected by way of a bi-directional transmission path formed by a wire pair. In a HDSL transmission system the number of such individual transceiver systems may be one or two or three in parallel, whereby in a case of two or three pairs in parallel the rate to be used in each parallel transmission connection is 2 Mbit/s sub-rate; 784 kbit/s if there are three pairs in parallel and 1168 kbit/s if there are two pairs in parallel. It is defined in international recommendations how signals of 2 Mbit/s level are transmitted in a HDSL system, such as, for example, VC-12 signals of a SDH network or 2048 kbit/s signals in accordance with the G.703/G.704 recommendations of the CCITT.

Since only such bit rates are achieved with the solutions mentioned above, which are typically in the order of 1...2 Mbit/s, a technique allowing ATM level bit rates has been sought for the subscriber line cable. A specification of VDSL equipment is in fact being made by the international standards institute ETSI (European Telecommunications Standards Institute). The intention is that a VDSL transmission connection implemented in a metal wire pair of a telephone network will be able to transmit ATM cells between a telephone network and a subscriber terminal.

With the VDSL technique, subscriber lines in telephone networks begin using so high frequencies that radio-frequency interferences induced on the subscriber line, which is typically an unshielded wire pair, become a problem.

It has been proposed that radio-frequency interferences be eliminated, for example, with the aid of an adaptive channel equalizer in the receiver. However, an accurate and expensive AD-converter is then needed, because the interferences, which must also be converted into digital form, may

be very strong. In addition, it would be difficult to adjust the equalizer, since the interference begins quickly and its frequency changes quickly.

Another known method of eliminating strong radio-frequency interferences is by using some manner of multicarrier modulation, where several carriers are brought about in a single modulation process (for example, DMT, Discrete Multitone, or DWMT, Discrete Wavelet Multitone) and by acting in such a way that bits to be transmitted are not allocated at all to those carriers which have interferences. DMT is a method of implementing an ADSL connection defined by ANSI (American National Standards Institute), where many such subchannels (carriers) are brought about in the same modulation process which are equally spaced in the frequency domain and have the same width. When it is desirable to eliminate interferences caused by fixed sources, for example, by amateur radio transmissions, those subchannels which are located on interfered bands (for example, amateur radio bands) are removed entirely from use. Such a solution is described in the international PCT application WO-A-95/28773.

A primary drawback of this solution is that it leads to either a complicated and expensive implementation or to an inefficient use of the frequency range. This is due to the fact that an efficient use of a non-continuous frequency range requires narrow subchannels, the number of which is high. An added number of subchannels for its part will make the system more complex. The efficiency of band utilization is also reduced by the circumstance that DMT subchannels will overlap partly in the frequency domain, whereby in order to eliminate interferences also such carriers must be taken out of operation which are outside the bands exposed to interferences. Implementation of multicarrier modulation methods is also complicated (forming and detecting signals are complicated processes).

Another drawback of the DMT-based solution is that padding bits (so-called cyclic prefix) must be added to the data to be transmitted for the elimination of distortions caused by the channel to be possible. Thus, DMT wastes capacity also in the time domain.

Summary of the invention

The purpose of the present invention is to bring about an improvement on the drawbacks presented above by providing a solution allowing a

very simple implementation of a transmission connection, especially a VDSL transmission connection, having a good performance.

This objective is achieved through a solution according to the invention which is defined in the independent claims.

The invention is based, firstly, on the insight that although use of a multicarrier modulator (DMT) is defined as a transmission method, for example, in the ADSL standard and it would thus be an obvious alternative also for the implementation of a similar but higher speed connection (a VDSL connection), it is not the most efficient or simplest way of implementing a transmission connection when the available frequency band is not continuous, but certain narrow frequency bands are not used. Secondly, the invention is also based on the insight that radio- frequency interferences caused by amateur radio stations in particular are especially strong, because amateur radio stations are usually located close to subscriber lines of telephone networks.

For these reasons, the invention does not start from the way of thinking that one must first bring about many carriers over the whole frequency band and then mask some of them out of use, but with the aid of the worst expected interference bands (that is, international amateur radio bands) the available transmission band is split up into clearly separated sub-bands, to each of which is given its own single-carrier modulation process or modulator, to which the (high-speed) bit stream to be transmitted is distributed. In this context, a sub-band thus means a transmission band which borders on an international amateur radio band at least at one of its edges.

The idea is thus with the aid of amateur radio bands to divide the frequency bands reserved for the connection into sub-bands to which the data is modulated. Each carrier is generated by its own modulator. Thus, in the frequency domain the channels are separated from one another and they may be handled independently of each other. The band reserved by each channel may thus be adjusted independently with the aid of carrier frequency and symbol rate.

In a method according to the invention it is possible to utilize some simple modulation method, preferably, for example, QAM (Quadrature Amplitude Modulation) or CAP (Carrierless Amplitude and Phase) modulation.

Brief description of the drawings

In the following, the invention and its advantageous embodiments are described in closer detail referring to examples shown in the appended drawings, wherein

Figure 1 illustrates a transmission system utilizing a VDSL connection;
Figure 2 illustrates a frequency division for use in the VDSL connection;
Figure 3 llustrates a transmission principle in accordance with the invention;
Figure 4 shows a division of sub-bands between transmission directions in accordance with an advantageous embodiment of the invention;
Figure 5 shows a basic form of apparatus for implementing a VDSL connection according to the invention; and
Figure 6 shows an advantageous embodiment of the apparatus shown in Figure 5.

Detailed description of the invention

As was mentioned earlier, ETSI, the international standards institute, is making a specification of VDSL equipment. Figure 1 illustrates the structure of a system utilizing a VDSL connection. The system architecture complies with the so-called FTTC (fiber to the curb/cabinet) structure. The cabinet or curb 11 receives data over a high-speed optical fiber connection indicated by reference number 12. Existing metallic lines (copper pairs) also pass through the same cabinet from exchange to subscriber. These copper pairs are indicated by reference number 13. In the optical network unit (ONU) located in the cabinet the high-speed data are combined onto the subscriber line so that the subscriber may still use old narrow-band POTS/ISDN services, but besides these a high-speed full-duplex data connection is available to him/her. These narrow-band and broad-band services are separated from one another by a (passive) filter, which performs frequency separation of VDSL signals and narrow-band signals. The VDSL connection proper is formed between the ONU and the network terminal NT. The network terminal is typically located on the premises of the end user (subscriber) and is connected to the subscriber's terminal equipment, for example, to an ordinary analog telephone or an ISDN telephone (reference number 15) or to a terminal equipment (TE) utilizing broadband services, such as, for example, a microcomputer (reference

number 16). The network terminal provides the end user with UNI (User to Network Interface) interfaces in accordance with the standard. This interface is indicated by reference mark INT1. The broadband VDSL interface provided by the optical network unit is indicated by reference mark INT2.

Since the present invention relates only to a VDSL connection to be implemented between the ONU and the network terminal NT, the system shown in Figure 1 will not be described more closely in this context. The VDSL system is described in greater detail, for example, in the ETSI report DTR/TM-03068, where the reader may find a description in greater detail, should he desire one.

In ETSI the following bit rates for VDSL transmission are agreed upon on a preliminary basis:

- downstream direction (from network to subscriber): 52, 26, 13 and 6.5 Mbit/s
- upstream direction (from subscriber to network): 26, 13, 6.5 and 2.3 Mbit/s.

The frequency division is made in accordance with Figure 2 so that on low frequencies space is left for existing POTS or ISDN services (frequency band A). The VDSL channels are transferred on frequency band B, the lower limiting frequency of which is typically 300...600 kHz and upper limiting frequency preferbaly about 18 MHz, as can be found out hereinafter. The division of sub-bands between different transmission directions of the VDSL connection will be described more closely hereinafter.

According to the invention, the bit stream transmitted to the VDSL connection is divided onto several carriers which are located on the frequency band so that they are placed on sub-bands limited by international amateur radio bands. Thus, the transmitter has several parallel modulators, wherein a suitable known modulation method, for example, QAM modulation is used. In each modulator an individual frequency is used so that the corresponding carrier is placed on the desired sub-band.

International amateur radio bands are presented in the following table, wherein the left column presents the lower limiting frequency of the band while the right column presents the upper limiting frequency of the band.

Lower limiting frequency (MHz) of the band	*Upper limiting frequency (MHz) of the band*
1.810	2.000
3.500	3.800
7.000	7.100
10.100	10.150
14.000	14.350
18.068	18.168
21.000	21.450
24.890	24.990
28.000	29.700

It follows from the frequency values presented above that in the method according to the invention the carriers are placed on the following sub-bands, the lower and upper limiting frequencies of which are determined according to amateur radio bands:

Sub-band No.	*Lower limiting frequency (MHz)*	*Upper limiting frequency (MHz)*
1	0.3	1.810
2	2.000	3.500
3	3.800	7.000
4	7.100	10.100
5	10.150	14.000
6	14.350	18.068
7	18.168	21.000
8	21.450	24.890
9	24.990	28.000

Figure 3 illustrates the transmission principle according to the present invention by showing the power spectral density (PSD) of a signal received from a VDSL connection when six different QAM-modulated carriers C1...C6 (sub-bands 1...6 mentioned above) have been used, so that the two lowest ones have been reserved for upstream transmission and the remaining ones for downstream transmission. The amateur radio bands are presented by orthogons provided with reference marks AB1...AB6. The values in the figure correspond with computer calculations done for a connection distance of 400 m. The power density of the VDSL connection was -60 dBm/Hz and its Additive White Gaussian Noise (AWGN) was on a level of -115 dBm/Hz. The heights of orthogons AB1...AB6 correspond with the calculatory magnitude of the interference when the transmission power is assumed to be 0 dBm and the band width is assumed to be 4 kHz.

The transmission rates of the VDSL connection mentioned above can be implemented by using the six lowest sub-bands (sub-bands 1-6). It is preferable to use the lowest sub-band (No. 1) in the downstream direction, because these low frequencies are used in this direction also in the ADSL system. In this way near end crosstalk (NEXT) is avoided, even if both ADSL connections and VDSL connections in accordance with the invention are in the same cable. An examination of the subscriber line with Shannon's law indicates that the above-mentioned transmission rates and the targeted connection distances mentioned in the above-mentioned ETSI report can be best achieved when choosing transmission directions for the sub-bands in accordance with the following table. (Shannon's law $C = B \times \log_2 (1 + S/N)$ tells which is the theoretical maximum information transmission capacity C on a channel, the band width of which is B and the signal-to-noise ratio of which is S/N.)

Sub-band No.	*Transmission direction*
1	downstream
2	upstream
3	downstream
4	upstream
5	downstream
6	downstream

Such division of transmission directions was arrived at by using Shannon's law for calculating firstly the capacities of different sub-bands at different connection distances (300 m, 500 m and 1500 m) and by then choosing sub-bands for transmission directions according to their totalled capacity and the bit rate desired in the transmission direction in question. It should be noticed that since attenuation in the cable increases quickly along with a growing frequency, a band on lower frequencies has a correspondingly better signal-to-noise ratio and, according to Shannon's law, also a higher information transmission capacity than a band of equal width at higher frequencies. As regards transmission capacity it is thus not possible to exchange, for example, directions between sub-bands 3 and 4, although the bands are of almost equal width.

The division described above is advantageous also in that it may be used both for symmetrical and asymmetrical connections, whereby there may be connections of each type in the same cable, without crosstalk from one connection to another. This advantageous frequency division is also illustrated in Figure 4 wherein sub-bands of the upstream direction are hatched.

A similar examination shows that if a mere symmetrical operation or alternatively a mere asymmetrical operation is sufficient, the VDSL connection may also be implemented so that the upstream direction is given to sub-bands of the lower end of the frequency band (band B, Figure 2), while the downstream direction is given to sub-bands of the upper end. If only symmetrical connections can be used, the 3.5...3.8 MHz amateur radio band is a good split frequency for an upstream/downstream channel division. If, on the other hand,

asymmetrical operation is considered important, it can be noted in a similar manner that the 1.810...2.000 MHz amateur radio band constitutes a suitable split frequency. Placing the crossover frequency at the 3.5...3.8 MHz frequency band allows implementation of a symmetrical bit rate of 26 Mbit/s and a bit rate of 52 Mbit/s in the downstream direction.

Figure 5 shows a basic form of apparatus according to the invention. The figure shows both ends of a VDSL connection seen in one transmission direction. The high-speed bit stream DATA_IN (the rate of which is, for example, 52 or 26 Mbit/s, according to the above presentation) to be transmitted to the VDSL transmission connection is fed to symbol-forming block 41, which forms symbols of the bits and divides the symbols onto different carriers by feeding them to modulator block 42, which comprises a number of n parallel QAM modulators A1...An operating at different carrier frequencies, according to Figure 3. Block 41 feeds the symbol which it has formed directly to the input of its corresponding modulator. Since the signal-to-noise ratio varies with different carriers, a different number of bits per symbol may be used with different modulators. The better signal-to-noise ratio a carrier has the more bits (denser constellation diagram) can be used.

When using the most preferable manner of implementation according to Figure 4, it is advantageous (a simple implementation of apparatus) for the implementation of apparatus to choose symbol rates, for example, so that in the upstream direction carrier C4 has a double symbol rate compared to carrier C2, while in the downstream direction carriers C3, C5 and C6 have a double symbol rate compared to carrier C1. Carriers C3 and C4 need not have an equal symbol rate, because transmission takes place in different directions. If, on the other hand, the upstream/downstream channel division is at the 3.5...3.8 MHz amateur radio band, the same symbol rate may be chosen for each carrier both in the upstream and in the downstream direction. If the limiting frequency is at the 1.81...2.0 MHz amateur radio band, then only one sub-band is in use in the upstream direction. In this case symbol rates for the downstream direction should be chosen so that on bands having frequencies in excess of 3.8 MHz a symbol rate is used which is twice the rate on the lowest 2.0...3.5 MHz band.

If the above-mentioned adaptive allocation of bits onto different carriers is used in the transmitter, it is worth while to add such a brief training

period to the starting phase of the connection which studies how many bits it is advisable to use per symbol on each carrier.

The QAM modulators modulate the signals to different carrier frequencies, which are located in some of the above-mentioned sub-bands 1...9, in each case preferably essentially in the middle of the frequency band in question. As the QAM modulation method is at the present time the most generally used modulation method, for example, in cable modems, it will not be described more closely in this context. Should the reader so desire, he may find a description of QAM in greater detail, for example, in the publication William Webb, Lajos Hanzo: Modern Quadrature Amplitude Modulation, Pentech Press, London, IEEE Press, New York, ISBN 0-7803-1098-5 (reference 1).

Output signals from the modulators are fed to summer 43, in which the signals are summed digitally. The digital sum signal is supplied further to line adapter unit 44 typically comprising in sequence a DA converter, a filter to remove harmonic components occurring in the digital signal, a line driver circuit to raise the output level of the signal to a correct level, a hybrid to separate the transmission and reception branches from each other, a line transformer and a (passive) filter (POTS/ISDN-splitter) to separate POTS/ISDN signals and VDSL signals from each other. The filter output is connected to a channel (wire pair).

At the receiving end the signal is connected first to line adapter unit 45 typically comprising the above-mentioned (passive) filter (POTS/ISDN-splitter), a hybrid to separate the transmission and reception branches from each other, an adjustable amplifier stage, a filter stage and an AD converter. The filter stage is preferably provided with so-called notch filters operating in amateur radio bands. Since the summer and line adapter units can be implemented in accordance with conventional techniques, their structure will not be described further in this context.

Digital words received from line adapter unit 45 are connected further to demodulator unit 46 comprising n parallel QAM demodulators B1...Bn, whereby n modulator/demodulator couples are formed (for example, carriers C1, C3, C5 and C6, whereby n = 4). Symbol words received from demodulator outputs are supplied to symbol identification circuit 47, which forms the original bit stream DATA_OUT of the baseband symbol words.

Should various delays of the carriers cause problems in the reconstruction of the original signal, the delays may be measured individually for each carrier at the initial stage of the connection and this information may be utilized in the reception to ensure a correct reception order for the symbols.

The apparatus presented in the foregoing can be modified further, for example, in accordance with the advantageous embodiments presented hereinafter.

It is advantageous in connection with the method to use trellis-coded modulation (TCM), because coding amplification is obtained in this way and performance differences between the carriers can be equalized. Trellis-coding is an advantageous choice also for the reason that it is known to be a very useful coding method, especially in transmission along telephone lines.

Figure 6 shows such an embodiment, wherein symbol-forming unit 51 also performs trellis-coding. Since trellis-coding is known per se, it will not be described further in this context. When desired, a description in closer detail can be found, for example, in reference 1 mentioned above. Since trellis-coding is performed at the transmission end, such decoding as, for example, Viterbi-decoding, is used at the reception end, as this is the usual decoding method in connection with trellis-coding. Thus, symbol identification unit 52 is provided with a Viterbi-decoder in this embodiment. The Viterbi-algorithm is described both in reference 1 and also thoroughly, for example, in the publication Benedetto, Biglieri, Castellani: Digital Transmission Theory, Prentice-Hall Inc., ISBN 0-13-214313-5 025.

It is also possible to level out performance differences between carriers by using the "gain scaling" method, that is, by using different transmission levels for different carriers. In practice, the transmitter's total power may be limited to a certain value (for example, 10 dBm), whereby it is advantageous to scale the transmission powers of different carriers so that the probability of bit error will be the same for them all. For this purpose, each modulator output is provided in accordance with Figure 6 with an adjustable amplifier AMP1...AMPn, allowing the transmitter's control part 48 individually to adjust the amplification of each carrier. In the initial situation the receiver informs the transmitter of the signal-to-noise ratios which it has measured, and based on these values the transmitter's control part adjusts the amplification of amplifiers AMP1...AMPn so that the bit error ratios are equal for each carrier.

Although the invention has been described in the foregoing by referring to examples shown in the appended drawings, it is obvious that the invention is not limited to these, but it can be modified within the scope of the inventive idea presented above and in the following claims. For example, an embodiment was described above wherein each sub-band has one carrier. Although this is the most advantageous method of implementation, it is possible in principle also to use more carriers per sub-band. Although amateur radio bands are international, the limits of some bands may vary somewhat in different countries, which means that the given band limits (which are in general use at least in Europe) must not be understood as quite exact limits.

Claims

1. Method for implementing a bi-directional wireline transmission connection, wherein the transmission connection is implemented in electric form so that there is a separate frequency range reserved from the transmission line (13) for each transmission direction,

characterized in that

the frequency band of the transmission line (13) is divided into sub-bands limited by international amateur radio bands (AB1...AB6) and the transmission connection is implemented at least on some of these sub-bands

(a) by generating a carrier with its own modulator for each sub-band to be used, and

(b) by dividing the bits of the bit stream (DATA_IN) to be transmitted between the modulators of the transmission direction in question so that each carrier is modulated with some of the bits.

2. A method as claimed in claim 1, characterized in that 1-2 carriers are used in the direction from subscriber to network and 1-5 carriers are used in the direction from network to subscriber.

3. A method as claimed in claim 2, characterized in that of the available sub-bands the six lowest ones are used so that from subscriber to network data are transmitted on sub-bands, the upper limiting frequencies of which are 3.5 MHz and 10.1 MHz, and from network to subscriber on sub-bands, the upper limiting frequencies of which are 1.81 MHz, 7.0 MHz, 14.0 MHz and 18.068 MHz.

4. A method as claimed in claim 1, characterized in that between two amateur radio bands only one carrier is used and in carrier modulation more symbol rates than one are used.

5. A method as claimed in claim 1, characterized in that adaptive bit allocation is used for different carriers.

6. A method as claimed in claim 1, characterized in that a different transmission power level is used for different carriers of the same transmission direction.

7. A method as claimed in claim 1, characterized in that trellis-coded modulation is used in the transmitter.

8. A method as claimed in claim 1, characterized in that the transmission connection is a VDSL connection.

9. Apparatus for implementing a bi-directional wireline transmission connection in electric form, which apparatus comprises for either transmission direction (a) means (41) for forming symbols of incoming bits (DATA_IN), and (b) modulator means (42) for modulating a carrier wave with the aid of formed symbols, whereby the apparatus uses a separate frequency range for each transmission direction, c h a r a c t e r i z e d in that the modulator means comprise n parallel modulators, the frequencies of which are chosen so that they form several carrier waves (C1...C6), each one of which in the frequency band of the transmission line is located in its own sub-band, each one of which is such that it borders on an international radio amateur band at least at its one end.

10. Apparatus as claimed in claim 9,

c h a r a c t e r i z e d in that each modulator (A1...An) is equipped with an adjustable amplifier (AMP1...AMPn) for individual adjustment of the power level of each carrier wave.

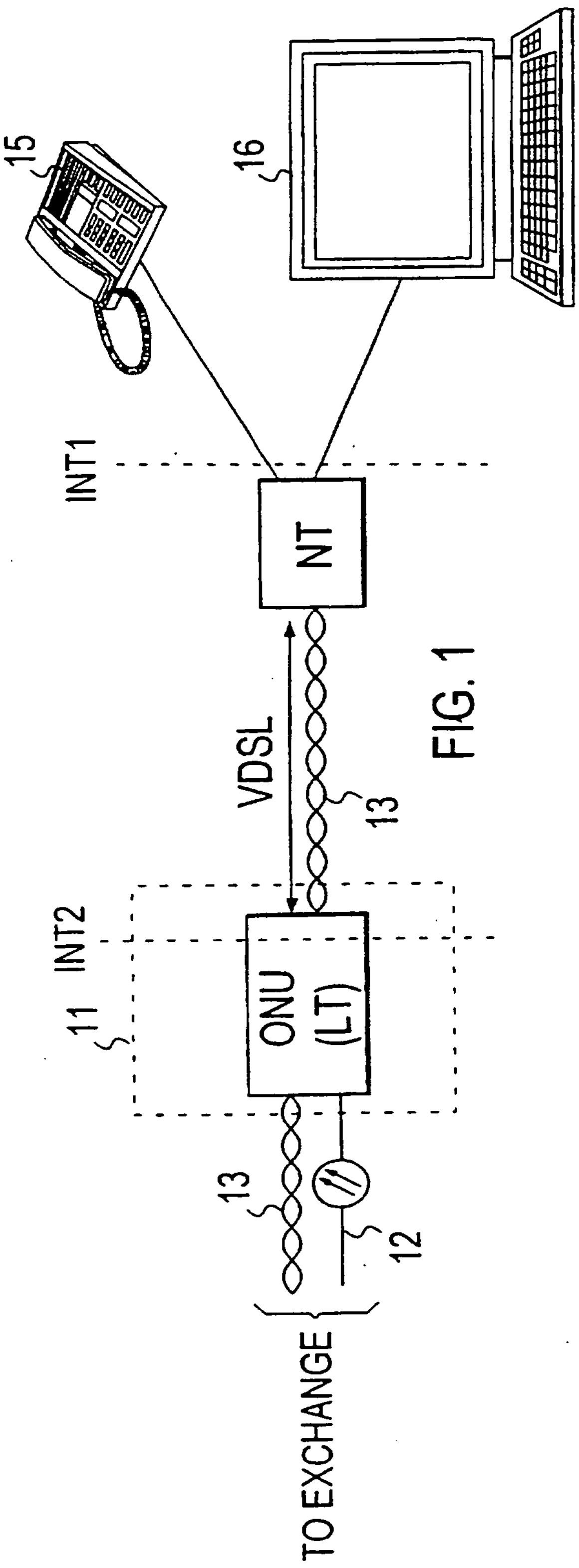
15
16
INT1
NT
VDSL
13
INT2
11
ONU
(LT)
13
12
TO EXCHANGE

FIG. 1

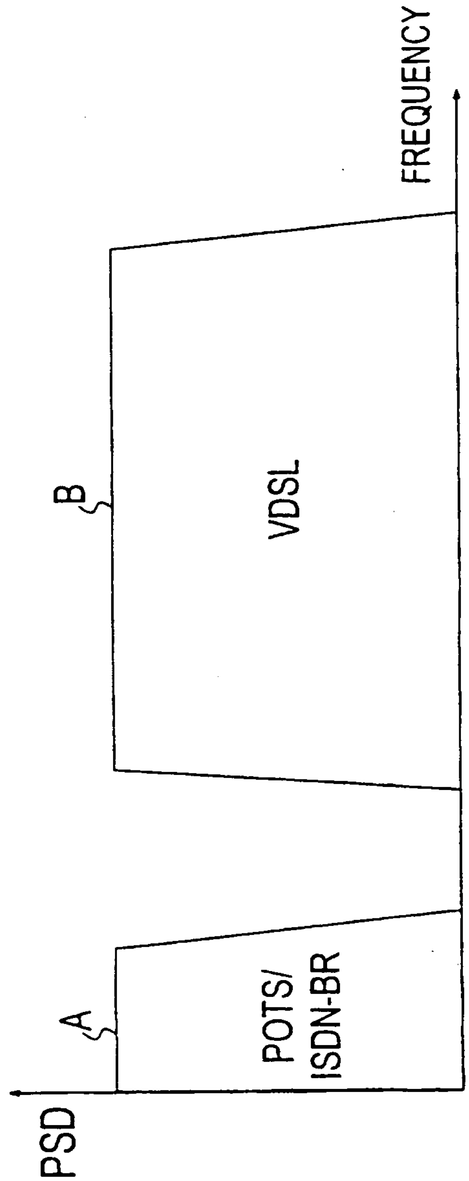
FREQUENCY
B
VDSL
A
POTS/
ISDN-BR
PSD

FIG. 2

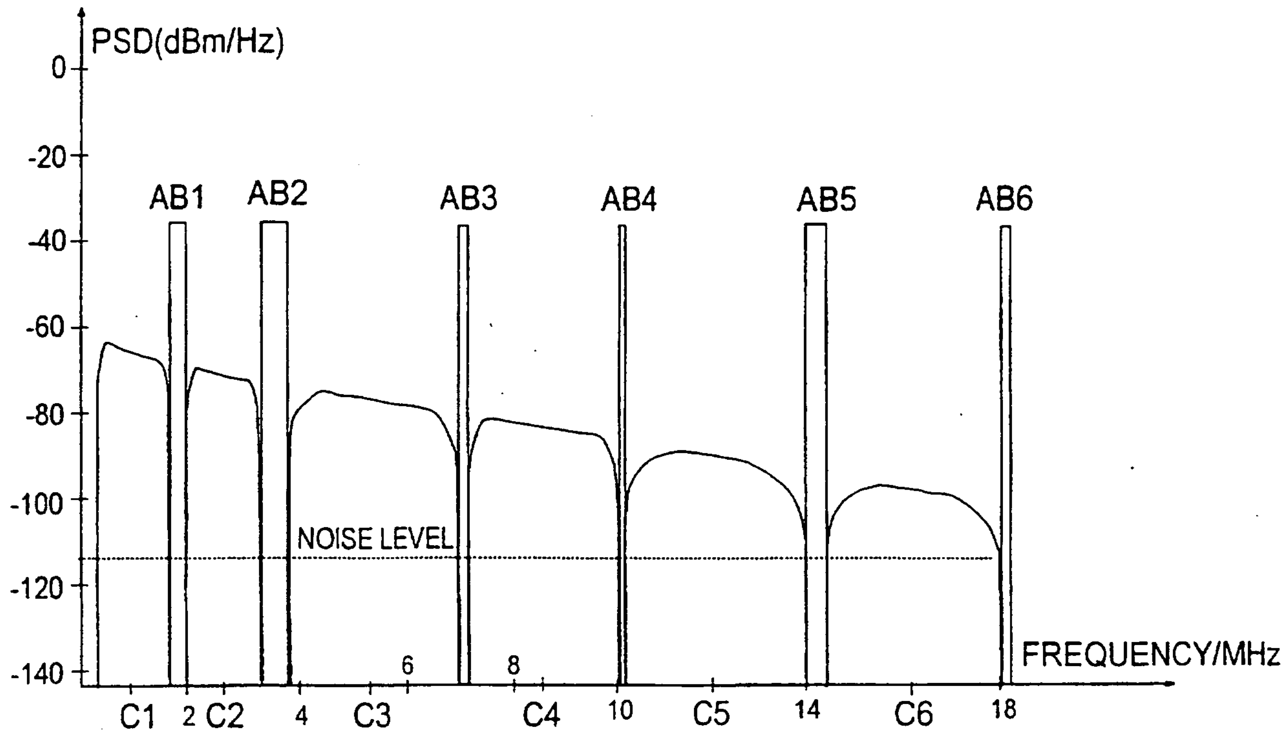
PSD(dBm/Hz)
0
-20
-40
-60
-80
-100
-120
-140
AB1
AB2
AB3
AB4
AB5
AB6
NOISE LEVEL
FREQUENCY/MHz
C1
2
C2
4
C3
6
8
C4
10
C5
14
C6
18

FIG. 3

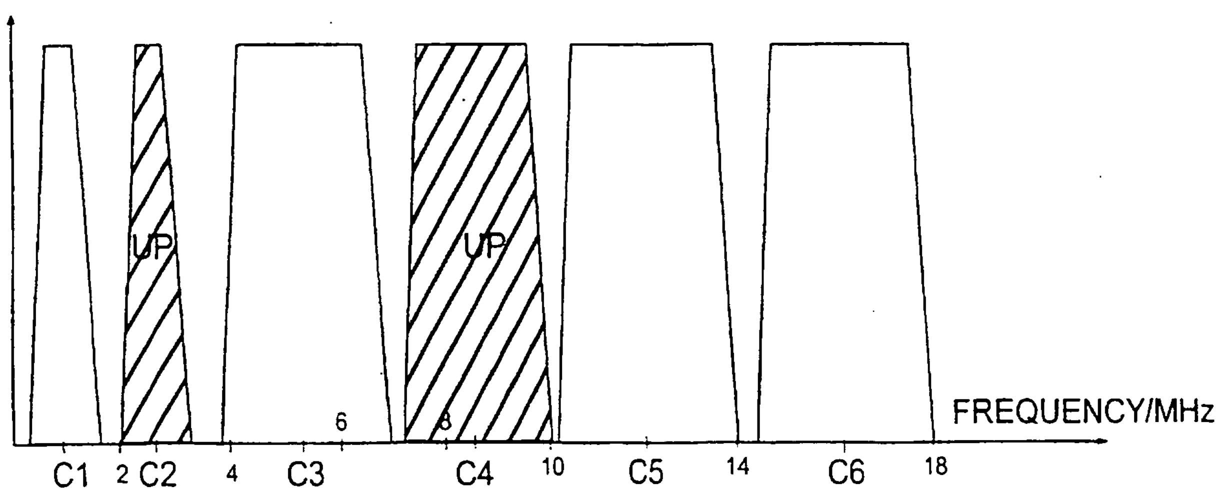
UP
UP
FREQUENCY/MHz
C1
2
C2
4
C3
6
8
C4
10
C5
14
C6
18

FIG. 4

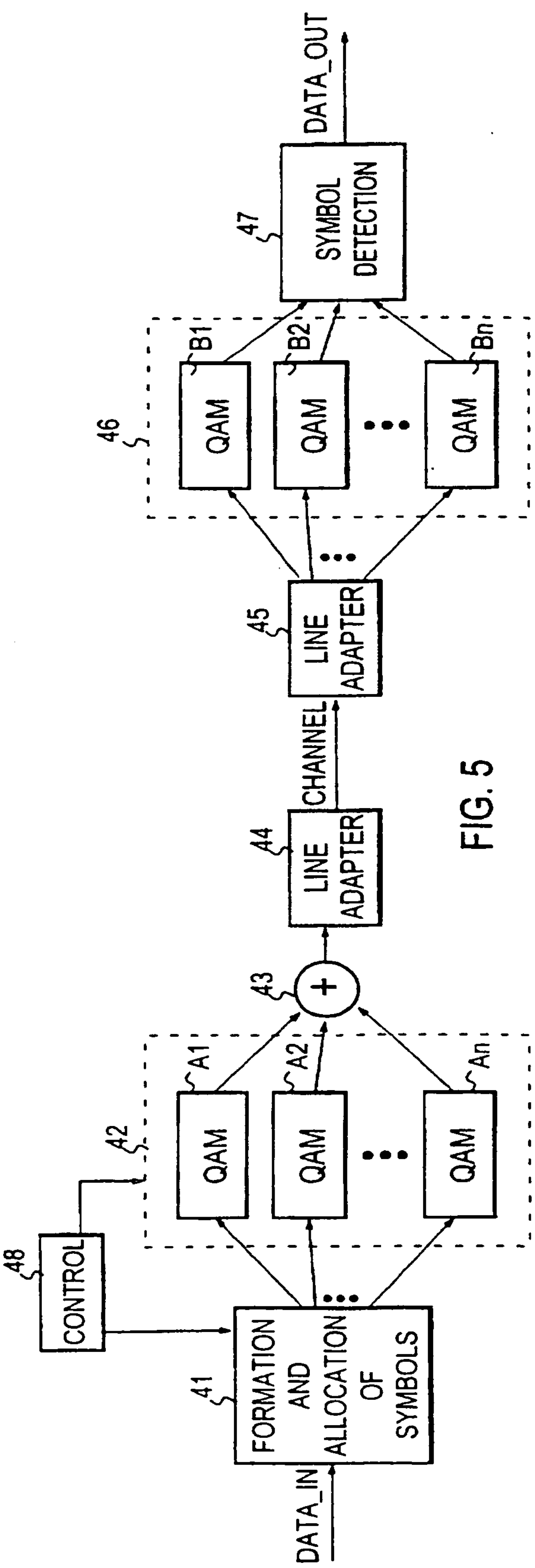
DATA_IN
41
FORMATION AND ALLOCATION OF SYMBOLS
48
CONTROL
42
QAM
QAM
QAM
A1
A2
An
43
+
44
LINE ADAPTER
CHANNEL
45
LINE ADAPTER
46
QAM
QAM
QAM
B1
B2
Bn
47
SYMBOL DETECTION
DATA_OUT

FIG. 5

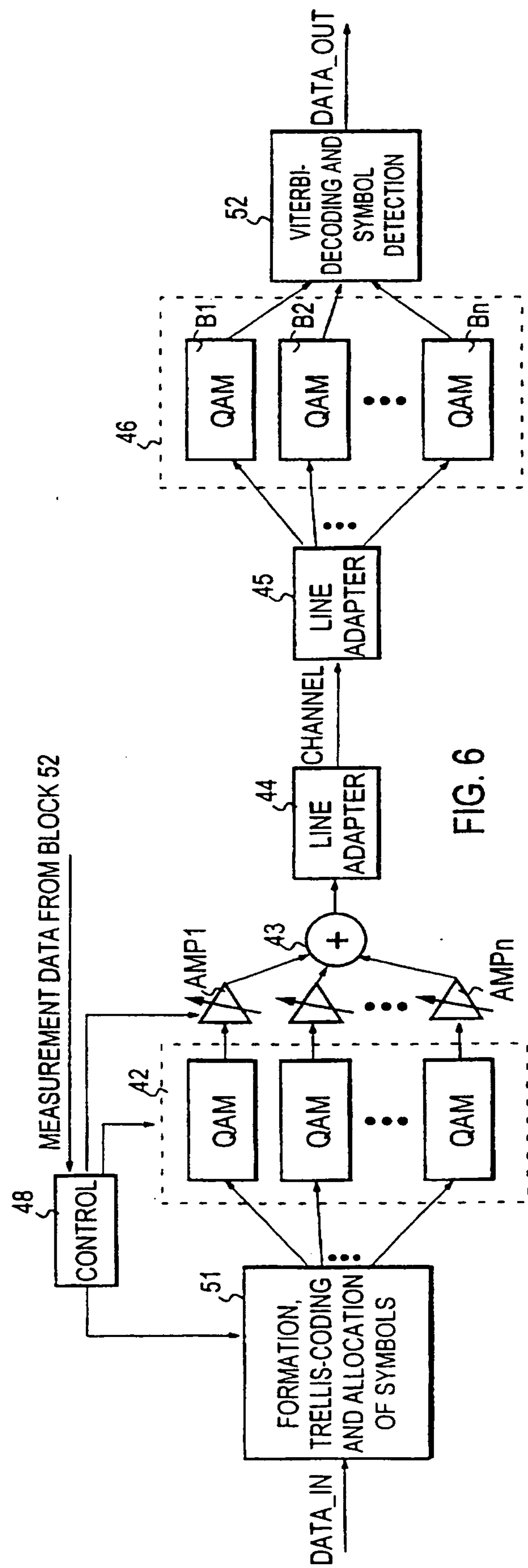
DATA_IN
51
FORMATION, TRELLIS-CODING AND ALLOCATION OF SYMBOLS
48
CONTROL
MEASUREMENT DATA FROM BLOCK 52
42
QAM
QAM
QAM
AMP1
AMPn
43
+
44
LINE ADAPTER
CHANNEL
45
LINE ADAPTER
46
QAM
QAM
QAM
B1
B2
Bn
52
VITERBI-DECODING AND SYMBOL DETECTION
DATA_OUT

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 97/00279

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04L 5/06, H04L 27/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0668679 A2 (ITALTEL SOCIETA ITALIANA TELECOMUNICAZIONI), 23 August 1995 (23.08.95), page 3, line 18 - page 5, line 5, abstract --	1-10
Y	WO 9528773 A1 (AMATI COMMUNICATIONS, INC.), 26 October 1995 (26.10.95), page 11, line 1 - line 13, abstract --	1-10
A	US 5479447 A (PETER S. CHOW ET AL), 26 December 1995 (26.12.95), abstract -- --------	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" erlier document but published on or after the international filing date
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- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 October 1997	16 -10- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer MIKAEL SOLLERHED Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/09/97

International application No.
PCT/FI 97/00279

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0668679 A2	23/08/95	EP 0679758 A	02/11/95
		IT MI940311 D,V	29/04/94
WO 9528773 A1	26/10/95	AU 2389395 A	10/11/95
		CA 2187753 A	26/10/95
		EP 0755601 A	29/01/97
		FI 964038 A	09/10/96
		US 5519731 A	21/05/96
US 5479447 A	26/12/95	NONE	